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Comment on angeo-2020-93

Anonymous Referee #2

Referee comment on "Influence of different types of ionospheric disturbances on GPS signals at polar latitudes" by Vladimir B. Belakhovsky et al., Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2020-93-RC2, 2021

Dear Authors,

your work is surely valuable because it deals with a quite high number of events detected at high latitudes, from auroral latitudes to polar cap. I had the same comment posted by the other referee inviting you to report the statistics on the entire events collection and I read you modified the manuscript accordingly.

My main concern is about the meaning of the phase scintillation index.

Electron density gradients result in refractive index variations, which give rise to refraction and diffraction processes distorting the original wave front of the received signals. Scintillations are the effects due to the diffractive (stochastic) process, while the bulk of the refraction is considered deterministic (Mushini et al., 2012 and references therein). The threat to GNSS signals is due to the stochastic contribution, identified by the S4 enhancement. What you are observing in your case studies are likely phase fluctuations (misinterpreted as phase scintillations), not (or weakly) accompanied by S4 (light) enhancements. This misinterpretation derives from the phase detrending adopted to compute σ_φ that is often not appropriate to account for the plasma velocity at high latitudes (Spogli et al., 2021; Ghobadi et al., 2020 and references therein). Indeed, a choice of the cutoff frequency at 0.1 Hz is often not appropriate to remove the plasma convection velocity at high latitudes. So, what you are observing with σ_φ maxima are phase fluctuations due to the presence of large scale irregularities (above the Fresnel radius) and cannot be considered scintillations. De Franceschi et al. (2009) have demonstrated the difficulty in finding the optimum cutoff frequency for statistical studies and they proposed to look for actual scintillations investigating the simultaneous occurrence of S4 and σ_φ increase.

I am aware of the confusion in the terms used in a number of papers (also among the ones you cite) but I think that after the recent debate (Rino et al., 2019; McCaffrey and Jayachandran, 2019; Ghobadi et al., 2020; Spogli et al., 2021) it is important not to call phase scintillation what is phase fluctuation. It is important also to stress that the scintillations are the real threats to GNSS signal propagation.

This implies a substantial revision of your paper following two possible (alternative) options: keep the selected events considering them as phase fluctuation occurrences, or select other events in which S4 levels (considering the elevation and the projection to the vertical, see comment below) greater than 0.25 occur. For the statistical description you could use the method adopted by De Franceschi et al. (2019).

Another option, much more demanding, is to recalculate the σ_φ finding the optimal cutoff frequency case by case. This could be also carried on in a future work.

About the way you analyse the GNSS data:

- Are you applying an elevation mask to minimize the multipath?
- Did you projected the scintillation indices to the vertical to minimize the geometrical effects as suggested by Spogli et al. (2013)?

Minor comments:

Line 45: "…in the magnetosphere tail and then **released** into the auroral ionosphere"

Lines 51-52: "At polar latitudes polar cap patches **can** produce severe ionosphere disturbances."

Lines 195-196: Reword the sentence "It was also analyzed the influence of GPS signals scintillations the polar cap patches propagating on the dayside".

Lines 243-244: "Possibly low values of amplitude scintillations at high latitudes are caused by the low elevation angles of GPS satellites at these regions."

The issue is the opposite! When the elevation is low the S4 could be higher because of the contributions from longer path from the transmitter to the receiver.

References

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